Exposure to volatile organic compounds, particulate matter and fungi in a composting plant

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BACKGROUND

Composting is an important process of solid waste management and it can be used for treatment of a variety of different wastes (green waste, household waste, sewage sludge and more).

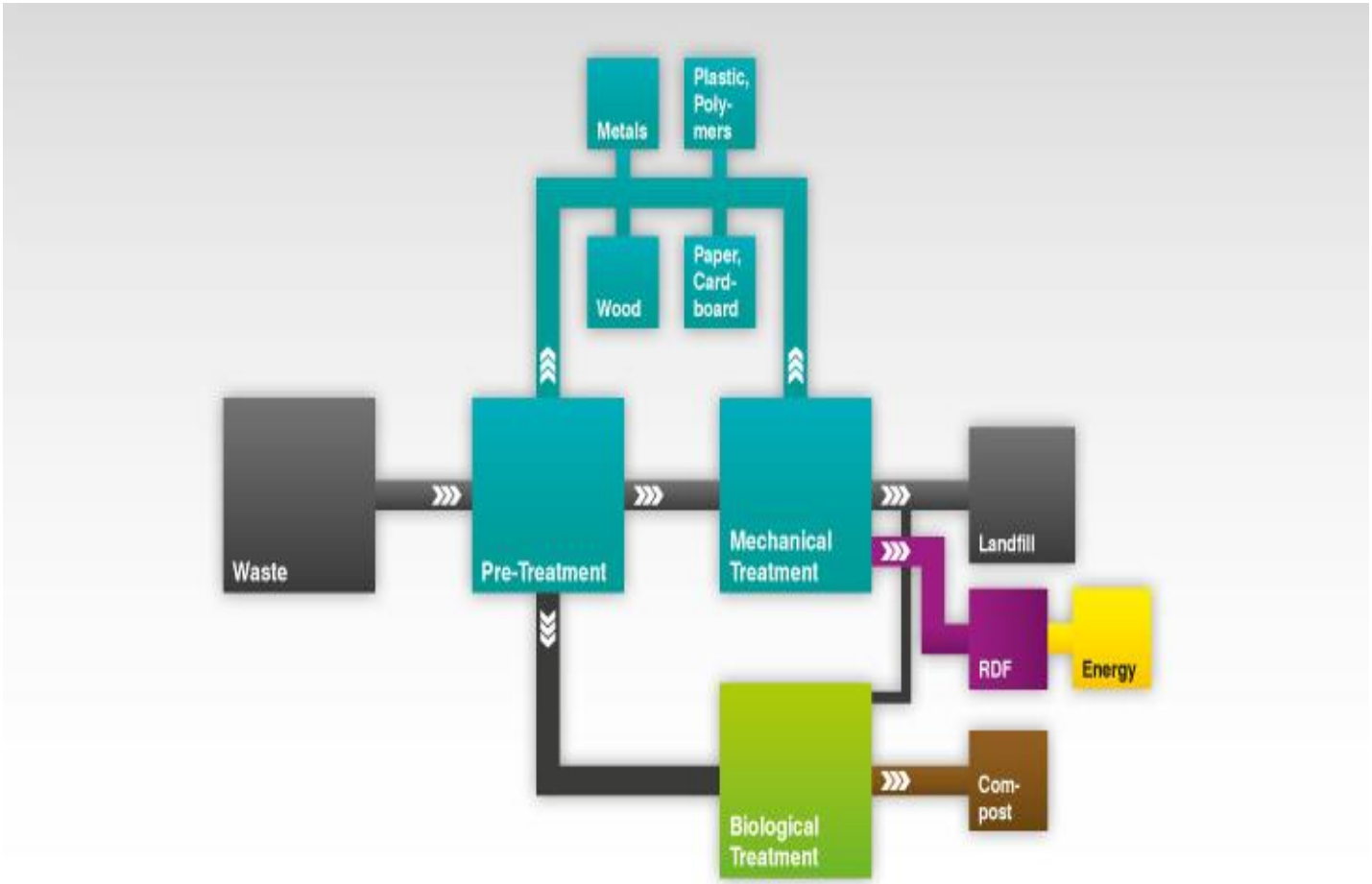
This process aims to :

- ✓ reduce the volumes of waste and ,
- ✓ create a valuable product which can be recycled as a soil amendment in agriculture and gardening .

Duquenne et al., 2012

BACKGROUND

A natural self-heating process involving the biological degradation of organic matter under aerobic conditions.



Fonte: www.kompoferm.com

BACKGROUND

The handling of waste and compost is responsible for the release of airborne microorganisms and their compounds in the air.

Possible contaminants:

- ✓ Dust
- ✓ Mesophilic and thermophilic microorganisms
- ✓ Volatile organic compounds
- ✓ Endotoxins and mycotoxins....

Tolvanen et al., 2005; Schlosser et al., 2009; Domingo and Nadal, 2009; Persoons et al., 2010; Sykes et al., 2011; Duquenne et al., 2012

Risk for workers of this occupational setting!

STUDY DEVELOPED

Aim: assess exposure/contamination to:

- ✓ volatile organic compounds (VOCs)
- ✓ particulate matter (PM)
- ✓ fungi.

In a composting plant located in Lisbon.

- ❖ An additional goal was to identify the workplace with higher level of contamination.

STUDY DEVELOPED

In a totally indoor composting plant.

The composting operations consisted:

1º Waste already sorted is unloaded in a reception area;

2º Pretreatment - remove undesirable materials from the process (glass, rocks, plastics, metals…).

3º Anaerobic digestion

4º Dehydration

5º Open composting with forced aeration.

All the process takes thirteen weeks.

MATERIALS AND METHODS

Measurements were performed in six workplaces:

- ✓ Maintenance workshop;
- ✓ Centrifuges;
- ✓ Maturation Park;
- ✓ Pre-treatment;
- ✓ Control room;
- ✓ Waste screw.

Places where workers spend more time.

MATERIALS AND METHODS

VOCs

- ✓ Portable direct-reading equipment (Wolfsense IQ-610- Graywolf Sensing Solutions; range: 0–10,000 ppm; accuracy: 3%).

AdvancedSense® Embedded Computer based Environmental Meters

- ✓ The mean, maximum and minimum values obtained in each location were considered.
- ✓ All measurements were performed near the workers' nasal area, at a height of about 1.5 m and during routine work.

MATERIALS AND METHODS

Particulate matter

- ✓ Direct-reading equipment (Lighthouse, model 3016 IAQ) to measure 5 different sizes ($PM_{0.5}$; PM_{1}; $PM_{2.5}$; PM_{5}; PM_{10}).

- ✓ Particle`s size is important to estimate with more detail the possible penetration of dust into and within the respiratory system.

WHO, 1999; Brunekreef and Forsberg, 2005

- ✓ Measurements done near the workers nose and during tasks.

- ✓ 5 min. measurement in all places: mean, maximum and minimum values obtained for each particle size.

MATERIALS AND METHODS

Fungi

- ✓ Air samples of 50L were collected through an impaction method
- ✓ Flow rate of 140 L/min onto malt extract agar supplemented with chloramphenicol (0.05%).
- ✓ Surfaces samples were also collected according to the International Standard ISO 18593 (2004).
- ✓ All the samples were incubated at 27ºC for 5 to 7 days.

RESULTS AND DISCUSSION

VOCs results

Waste Screw obtained the higher values (mean – 20.8 ppm), probably due to the huge amount of waste being crushed.

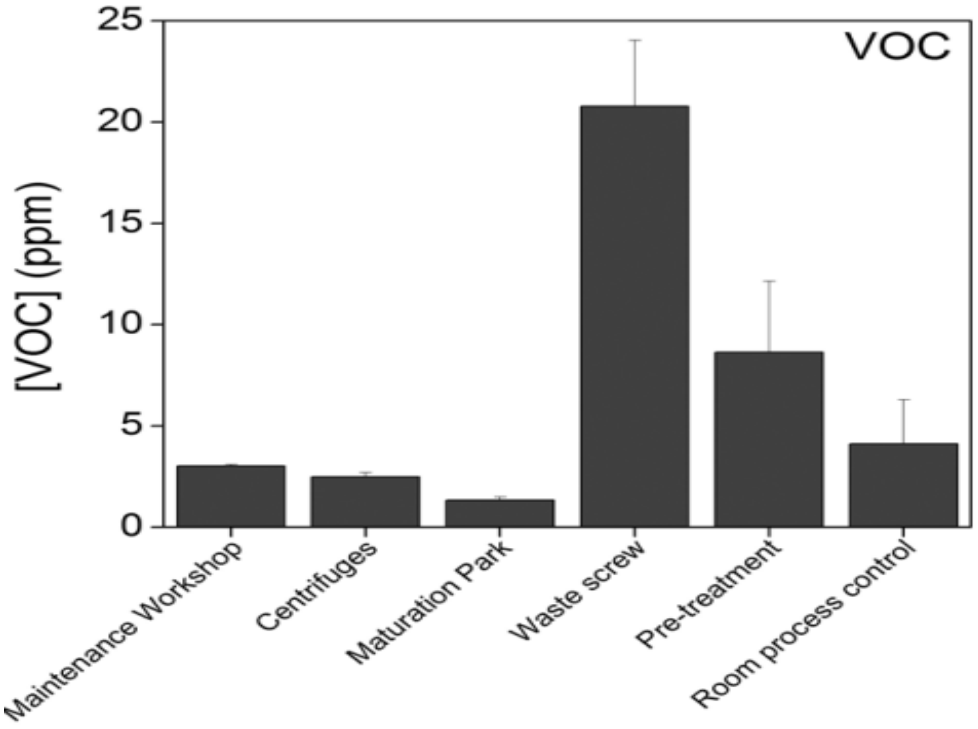
Table 1 - VOCs results obtained in each workplace (in ppm)

	Control Room	Pre-treatment	Waste screw	Maturation Park	Centrifuges	Maintenance Workshop
Mean	4.1	8.6	**20.8**	1.3	2.5	3.0
Range	2.5-7.9	1.2-12.2	**16-27.1**	1.1-1.7	2.3-3	3.2-2.9

RESULTS AND DISCUSSION

VOCs results

- ✓ Control Room and Pre-treatment workplaces also had high VOC concentrations
- ✓ These two places are more problematic because workers spend more time than in Waste Screw workplace.



WHAT CAN BE THE COMPOSITION OF THE MIXTURE OF VOCs?

✓ Benzene, styrene, formaldehyde among others are usually present.

Déportes et al., 1995; Herr et al., 2003; Albrecht et al., 2008; Nadal et al., 2009

✓ Presence of these contaminants is explained by accumulation and/or operational processes for treating the organic fraction of waste.

Déportes et al., 1995; Eitzer, 1995

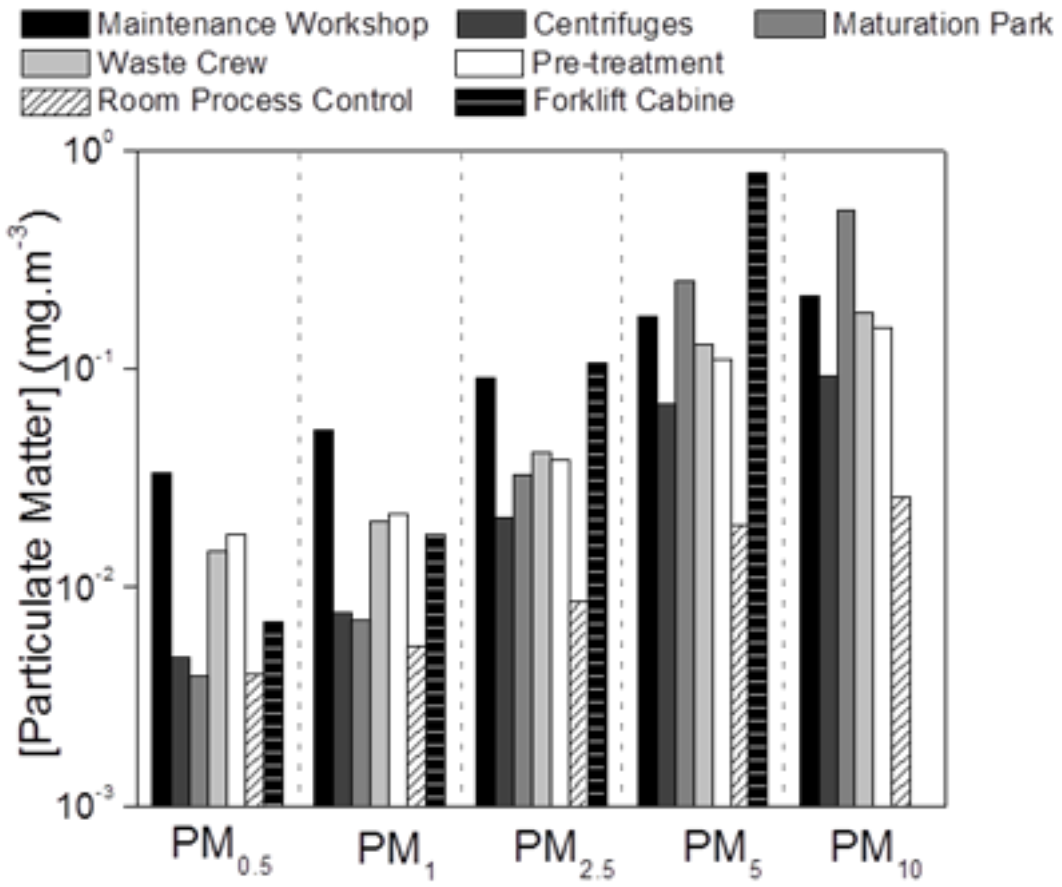
✓ VOCs can have different emission sources, namely:

- organic waste decomposition process;
- presence of bacteria and fungi;
- machinery (trucks, forklift) used to transport waste in the plant (exhaust gases).

RESULTS AND DISCUSSION

Particulate matter results

- ✓ Forklift Cabinet with higher values for $PM_{2.5}$, PM_5 and PM_{10}.
- ✓ Maintenance Workshop higher values for $PM_{0.5}$ and PM_1.
- ✓ Room Process Control presented the lowest values.





WHAT CAN BE THE EFFECT OF EXPOSURE TO THIS TYPE OF PM?

There are negative health effects demonstrated in literature, namely:

- ✓ penetration into the gas exchange region of the lung (PM_5)

- ✓ possibility to produce disease by impacting in the upper and larger airways below the vocal cords (PM_{10})

Vincent and Mark, 1981; Brunekreef and Forsberg, 2005

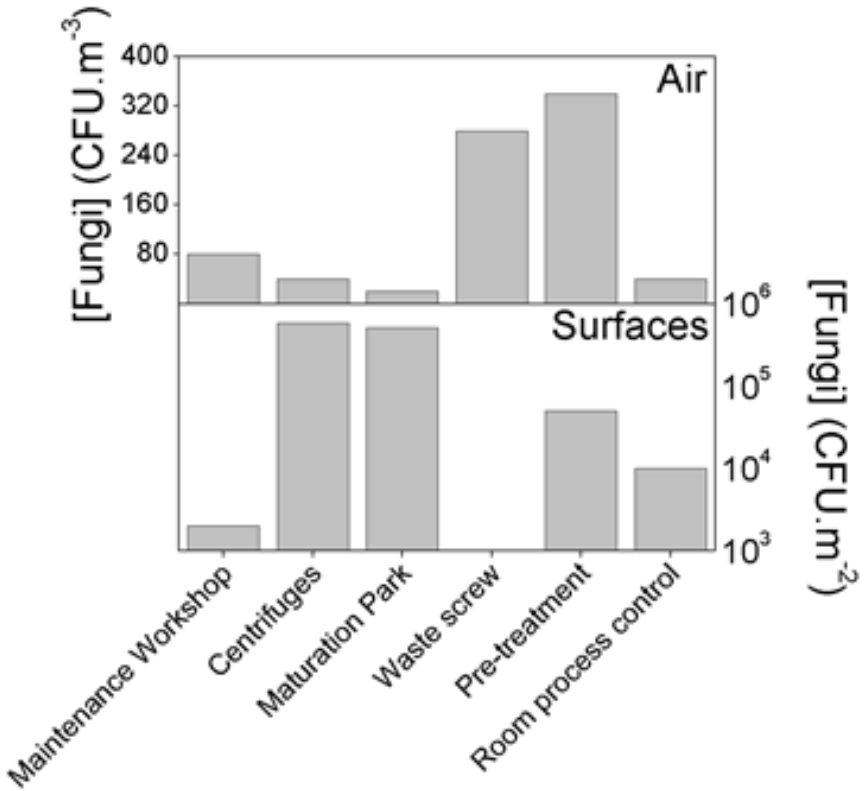
- ✓ $PM_{2.5}$ is also a concern, being already in the respiratory fraction can penetrate in the alveolar region and be involved in systemic effects.

Brunekreef and Forsberg, 2005

RESULTS AND DISCUSSION

Fungi results

- ✓ Pre-treatment and Waste Screw were the sampling sites with the highest fungal load in air.
- ✓ Centrifuges and Maturation Park has the highest fungal load in surfaces samples.



WHAT MEANS THE FUNGAL CONTAMINATION FOUND?

- ✓ There are no guidelines set by the NIOSH concerning the allowable load at the workplace.

Vilavert et al., 2009

- ✓ WHO considers the value of 150 CFU.m^{-3} as a reason for concern, especially when potentially pathogenic species of fungi are present.

Goyer et al., 2001

- ✓ Pretreatment and Waste Screw sampling sites surpass the WHO value.

MOST IMPORTANT CONCLUSIONS

- ✓ Workers are exposed simultaneously to several VOCs and the health effects of possible synergetic reactions are not known.
- ✓ High values of PM were observed with particular emphases in Forklift Cabinet.
- ✓ High fungi contamination: 3 from the 6 workplaces presented higher fungal load than outdoor sample meaning that there are sources of indoor fungal contamination.
- ✓ PM may act as a carrier and a source of nutrients for fungi and bacteria and can also promote exposure to their metabolites: mycotoxins and endotoxines.

Mayeux, 1997; Seedorf et al., 1998; Halstensen et al., 2013

ACTIONS TO ELIMINATE/CONTROL EXPOSURE

VOCs

- ✓ Improve ventilation systems (higher ventilation rates);

- ✓ Substitute the type of vehicles that make the transport of waste inside the building, avoiding the emission of exhaust gases.

Particulate Matter

- ✓ Keep roads, areas and equipment clean;
- ✓ Enclose and ventilate potentially dusty process areas;
- ✓ Maintain closed cabin door or windows from forklifts;
- ✓ Provide masks for workers.

Fungi

Impossible to eliminate!

- ✓ Reduce exposure to PM.

RESEARCH NEEDS

- ✓ More specific and sensitive analytical resources particularly for VOCs.
- ✓ Definition of more detailed sampling strategies to better characterize exposure to the risk factors.
- ✓ Exposure to mycotoxins and endotoxins?
- ✓ Possible health effects related with exposure to all these (and others) risk factors simultaneously?

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